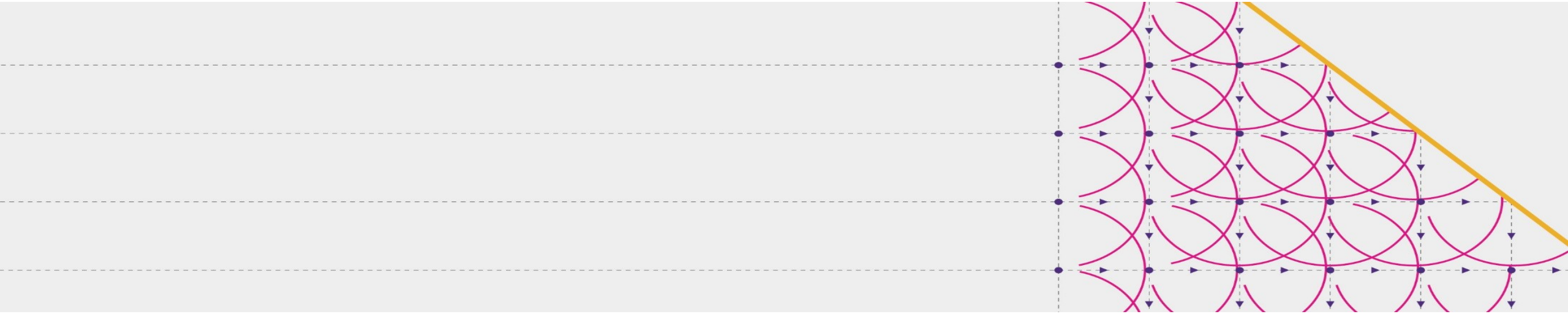
CAWE 2018

Current activities of ITU-R Study Group 3 and UK contributions

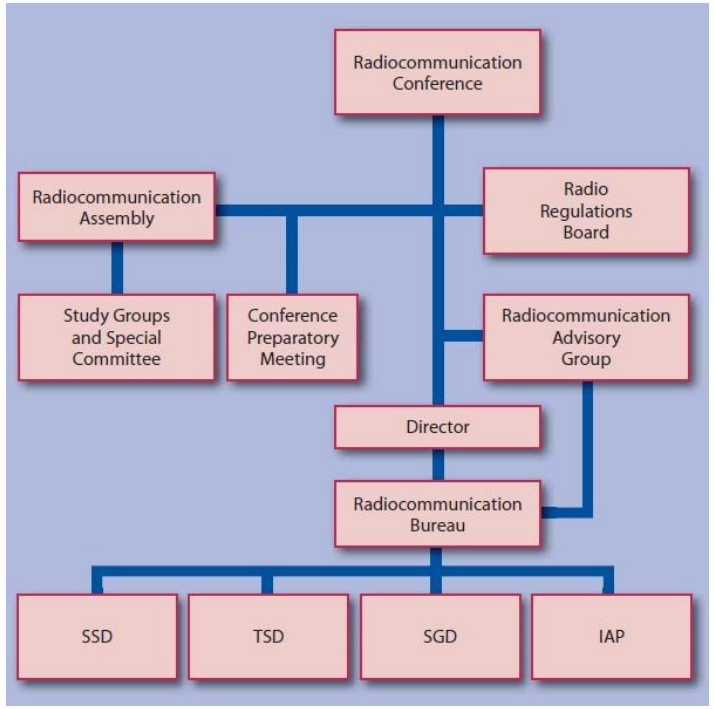
Richard Rudd



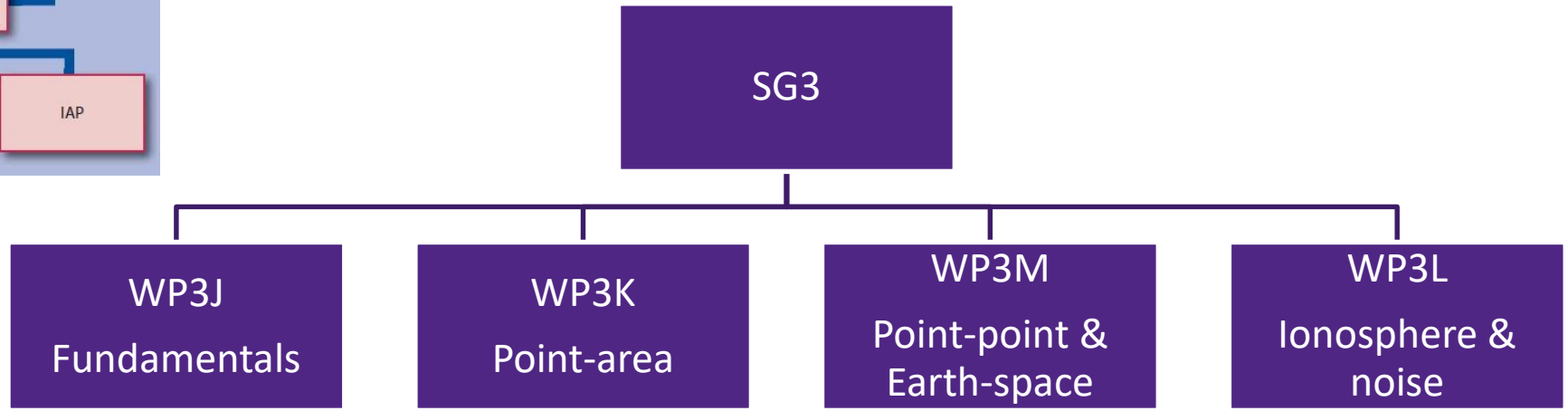
Outline

- ITU-R context
- ITU-R structure
- Building loss model
  - Refinements
  - Extensions
- ‘Clutter’ model
- Ofcom area measurements
- Vegetation loss
- Hydrometeor scatter
- Other models

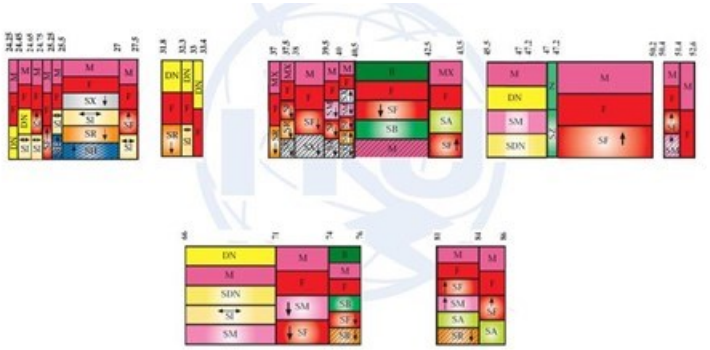
ITU-R Structure

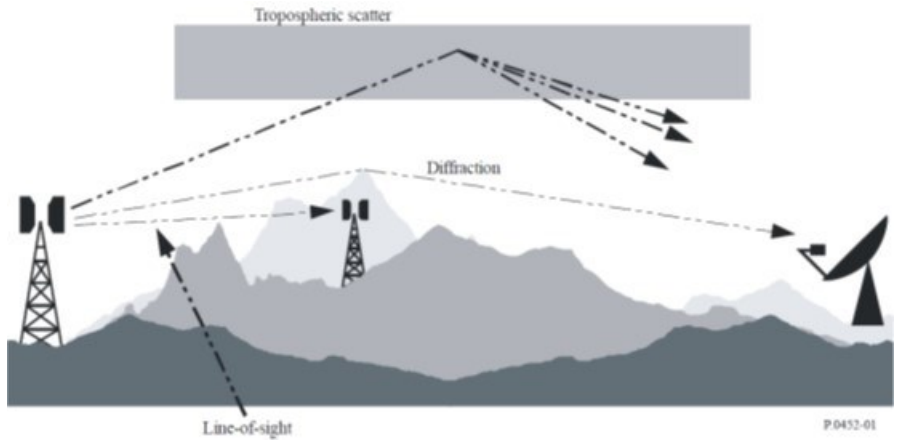


SG 1: Spectrum management
SG 3: Radiowave propagation
SG 4: Satellite services
SG 5: Terrestrial services
SG 6: Broadcasting service
SG 7: Science services



Drivers for ITU-R models (Recommendations)



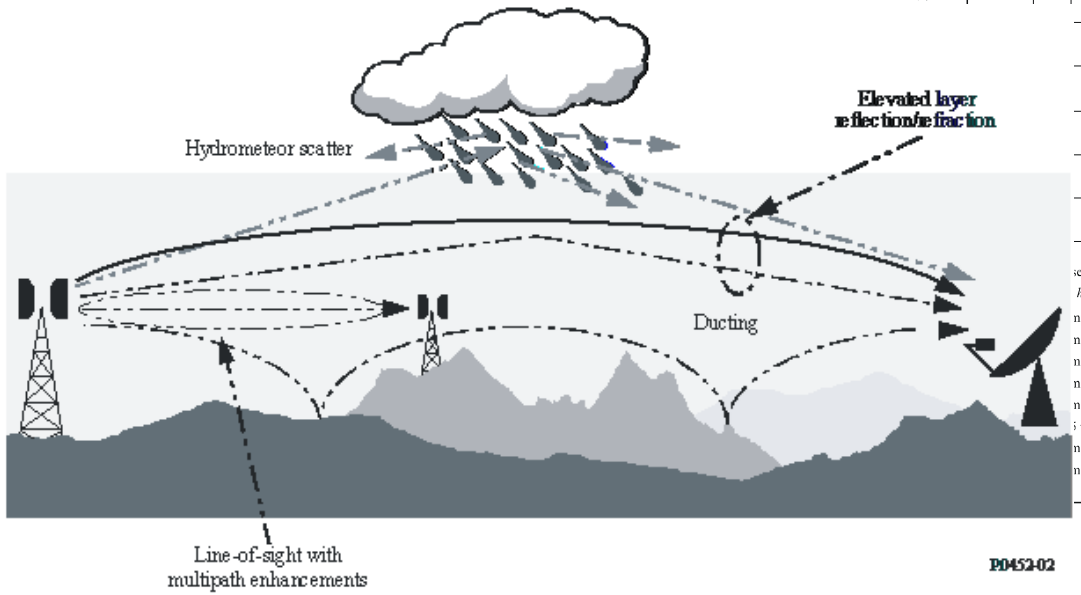


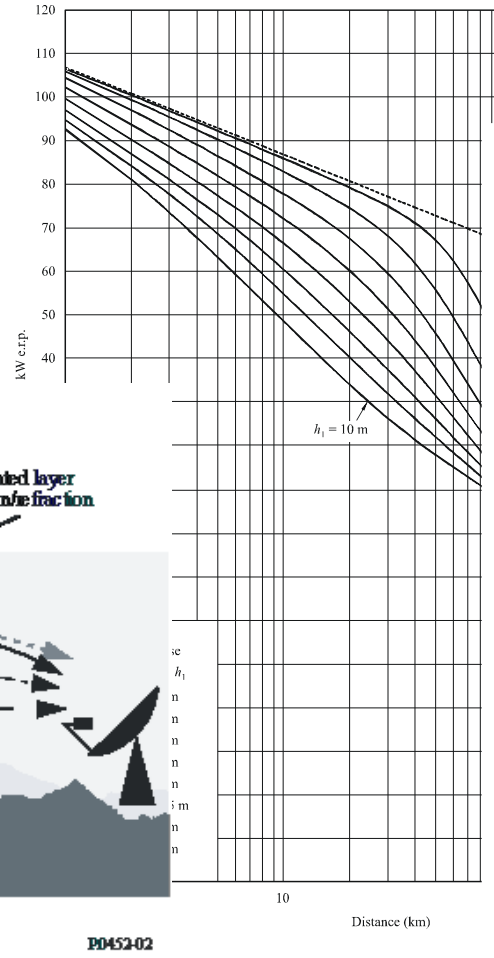
ITU Recommendations - generalities

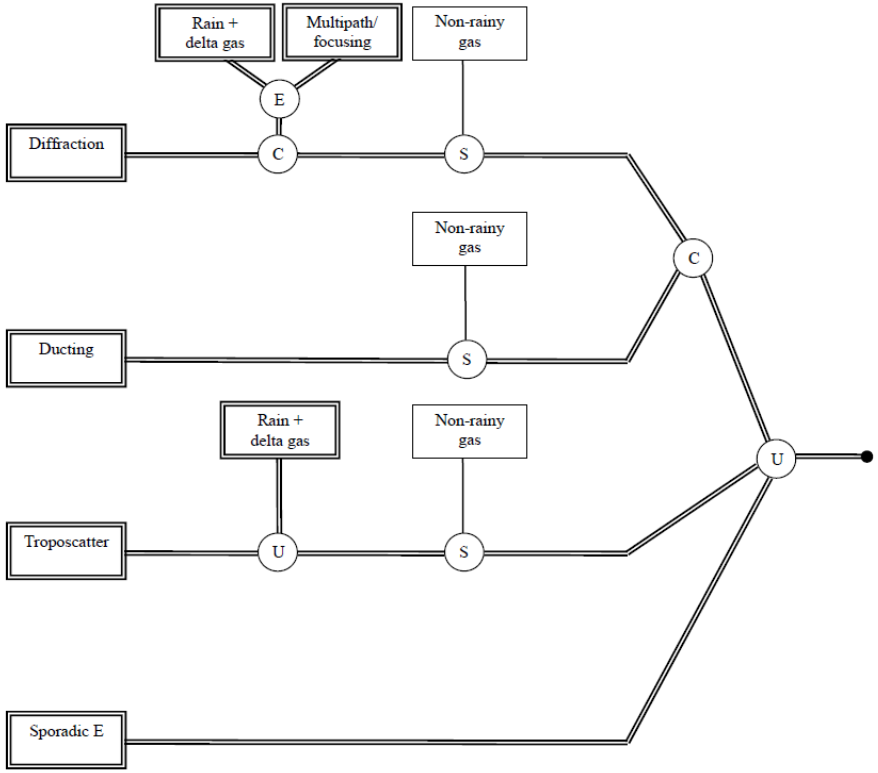
- ITU policy is that no references are given…
  - Recommendations are presented as Platonic truth!
  - Students sometimes compare their results to ‘ITU models’, unaware that these may simply represent a single, unrepresentative measurement point!
- Once-upon-a-time, the basis of Recommendations was given in associated Reports, but this practice fell out of favour (why?)
  - We should encourage the greater use of supporting Reports & Fascicles

UK contributions to SG3

- Historically very involved
  - BBC -> P.370 (Broadcast planning)
  - BT -> P.452 (microwave interference)
  - RAL / Ofcom -> P.2001 (General purpose)

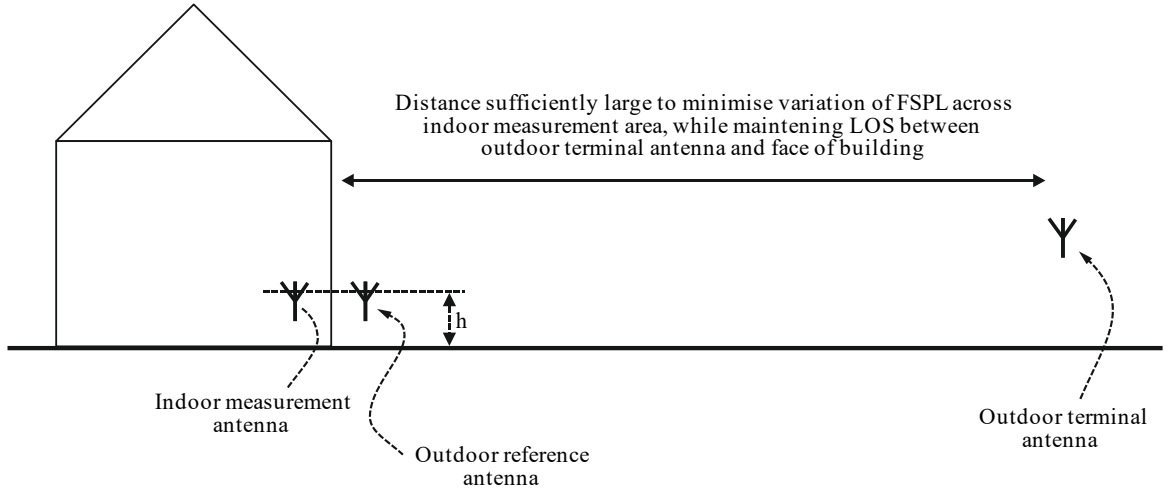






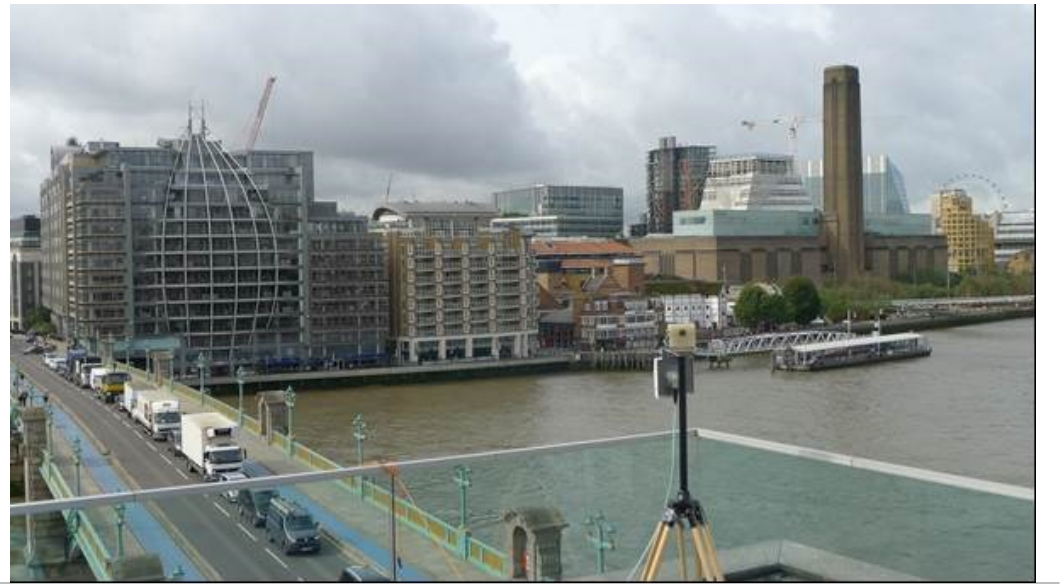
Building loss model

- Multiple definitions existed, scattered through Recommendations
  - No guidance on characterisation of variability
- Now harmonised in P.2040
  - *".. the additional loss due to a terminal being inside a building"*
  - "*Building entry loss can be measured as the difference [...] between the spatial median of the signal level outside the illuminated face of a building and the spatial median of the signal level inside the building at the same height above ground*"



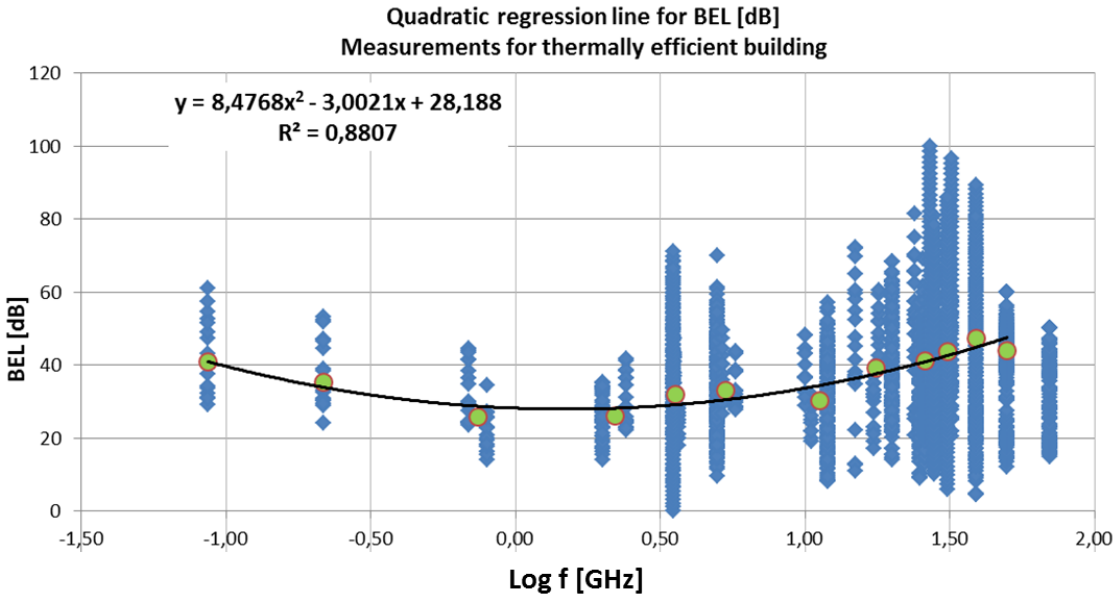
UK measurements

- At the Buildings Research Centre (BRE), Ofcom, retail parks, etc



Building loss model

- Median loss
  - Systematic comparison of 23 sets of measurement data
  - Simple quadratic fit found appropriate

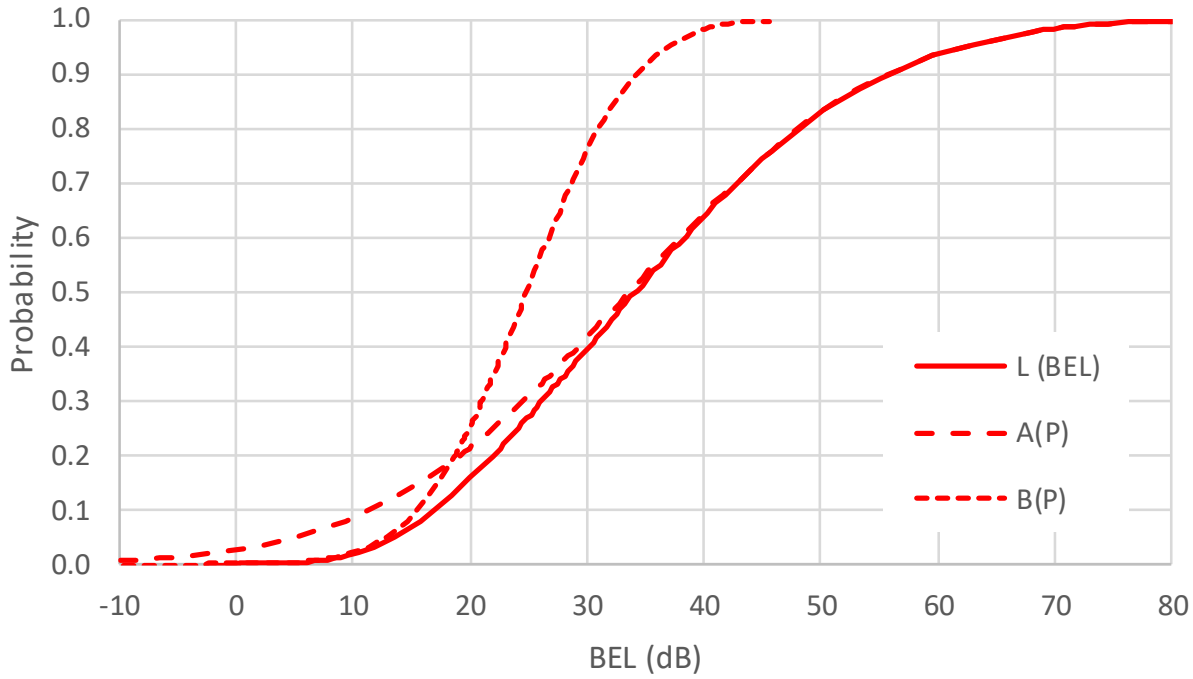


Final model (Recommendation P.2109)

- Blend of two lognormal distributions as power sum, with clamp

$$L_{BEL}(P) = 10\log(10^{0.1A(P)} + 10^{0.1B(P)} + 10^{0.1C}) \text{ dB}$$

$$A(P) = F^{-1}(P)\sigma_1 + \mu_1$$
$$B(P) = F^{-1}(P)\sigma_2 + \mu_2$$
$$C = -3.0$$
$$\mu_1 = L_h + L_e$$
$$\mu_2 = w + x\log(f)$$
$$\sigma_1 = u + v\log(f)$$
$$\sigma_2 = y + z\log(f)$$



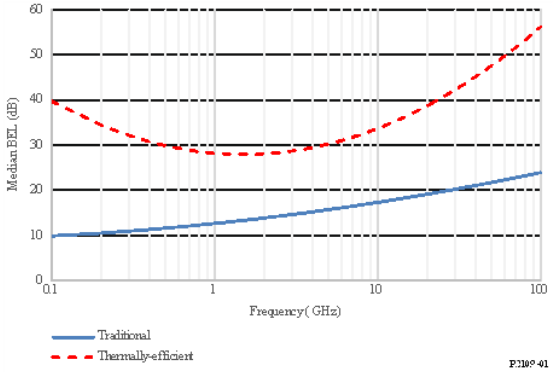
L_h is the median loss for horizontal paths, given by:

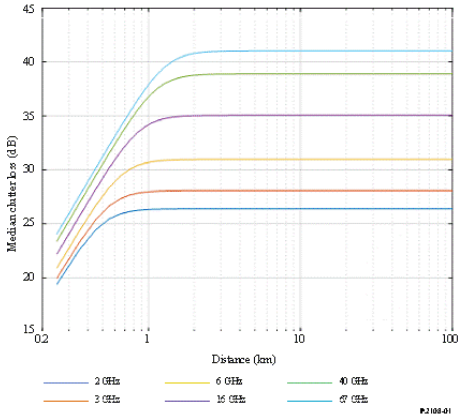
$$L_h = r + s\log(f) + t(\log(f))^2$$

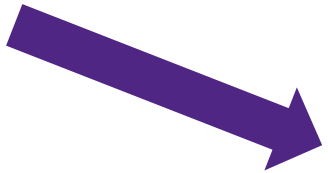
L_e is the correction for elevation angle of the path at the building façade:

$$L_e = 0.212\,|\theta|$$

Building loss & clutter – where next?







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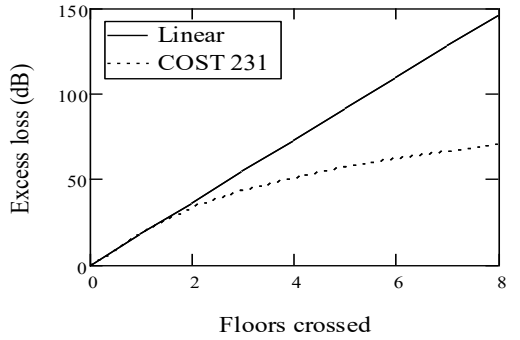
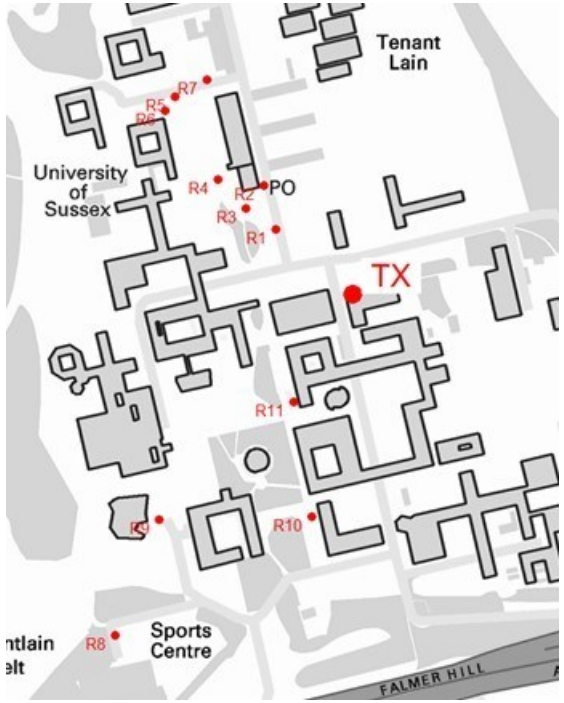
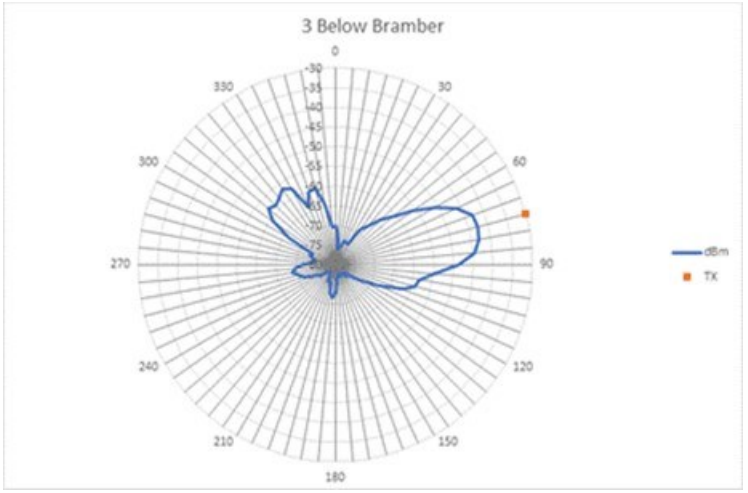


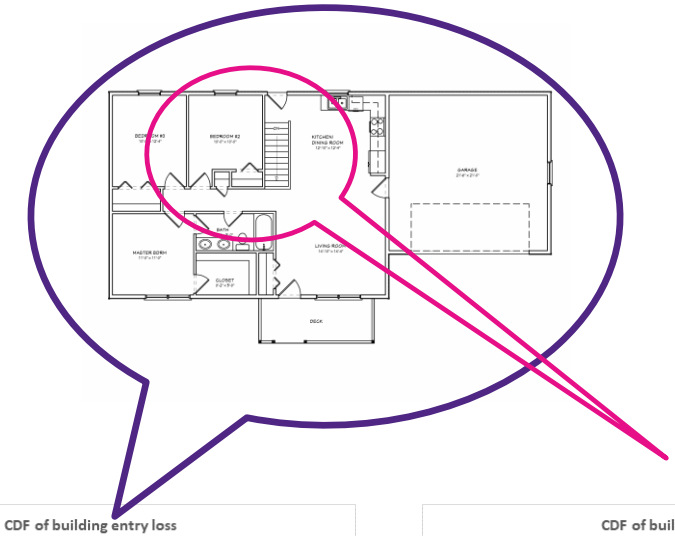
Clutter measurement and modelling

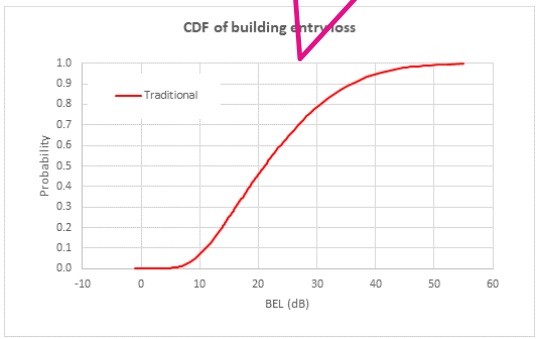
- 27 GHz
- AoA measurements in varied environments

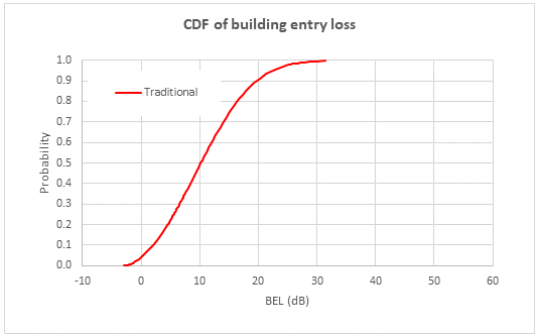




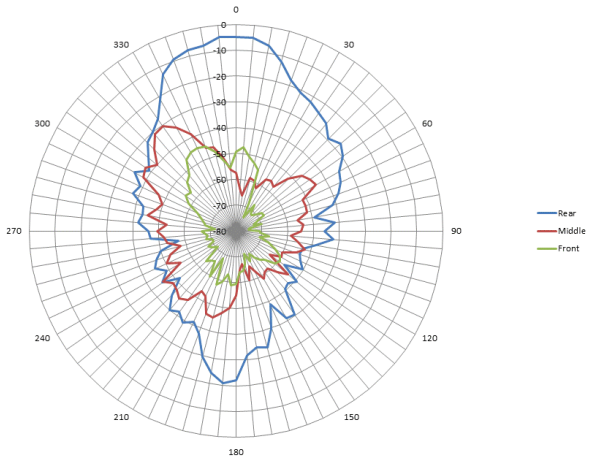
Treatment of variability

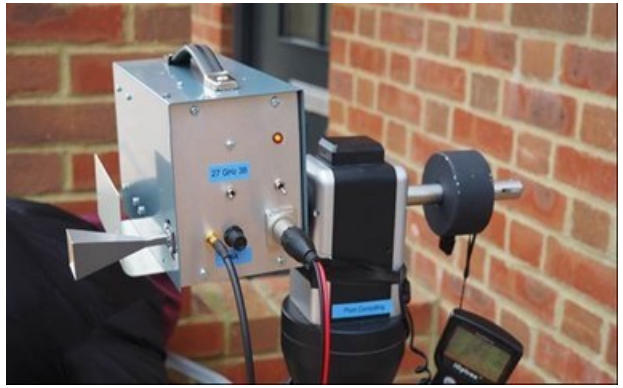


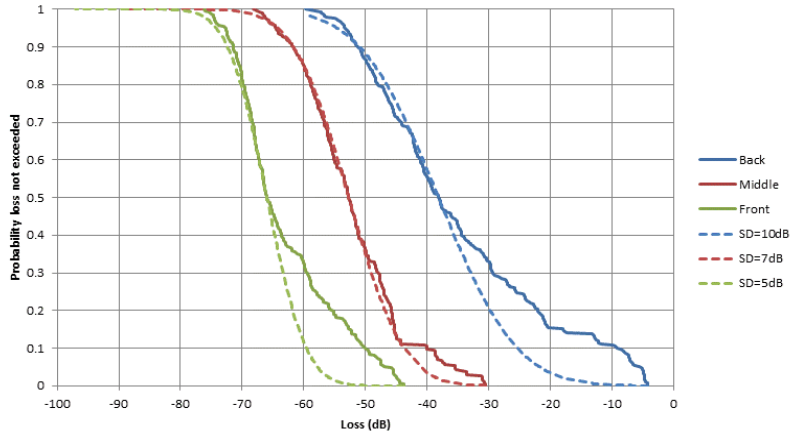




Assumptions regarding antennas?



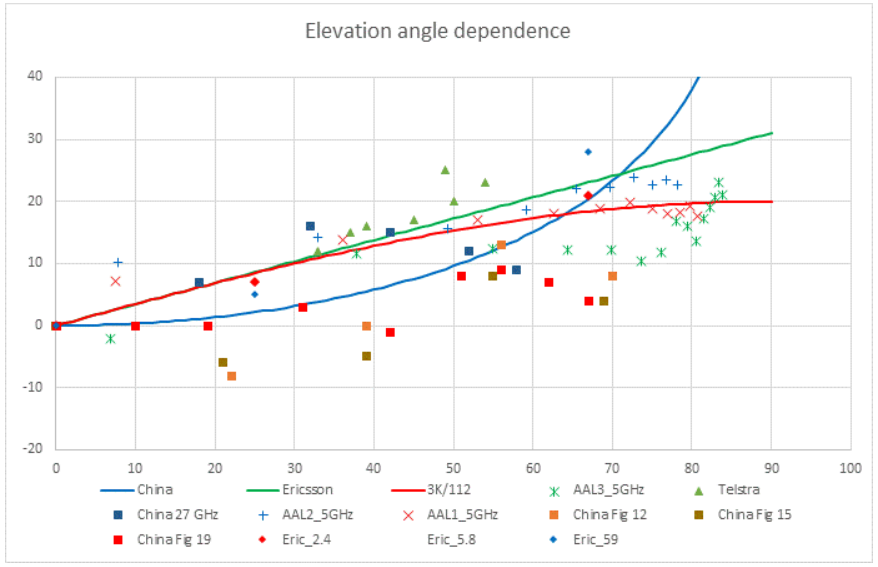


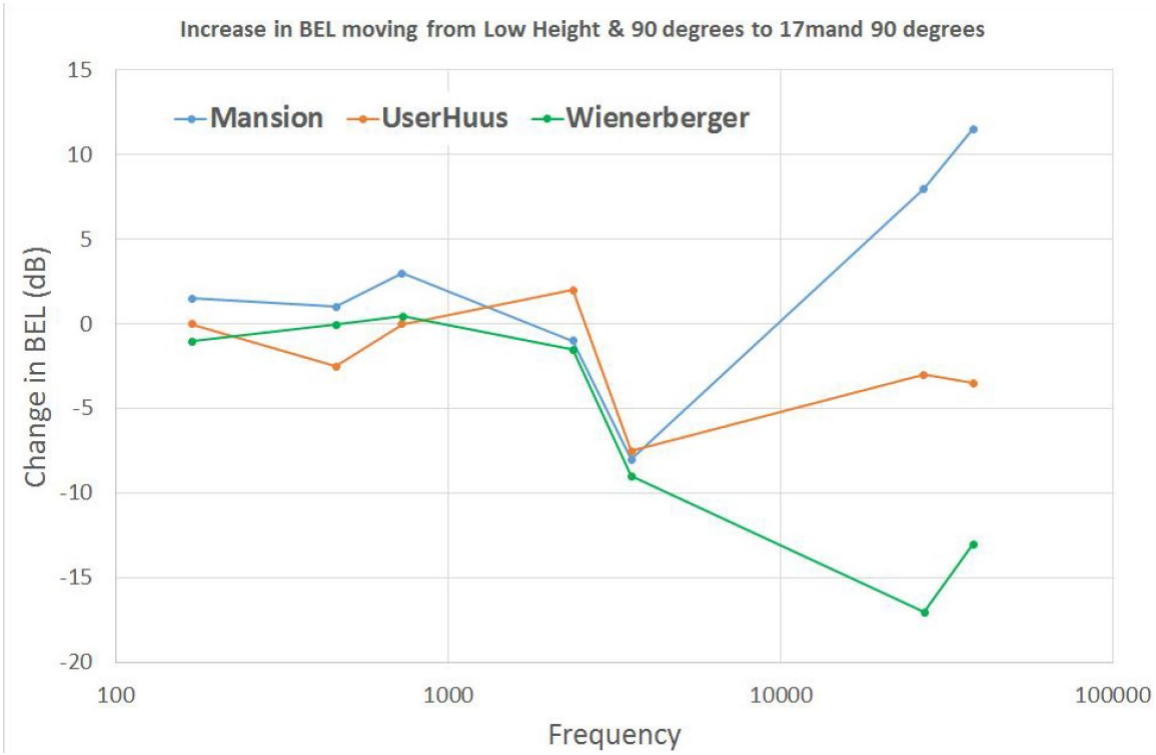


More data required!

- Greater diversity of buildings
- Elevation angle dependence

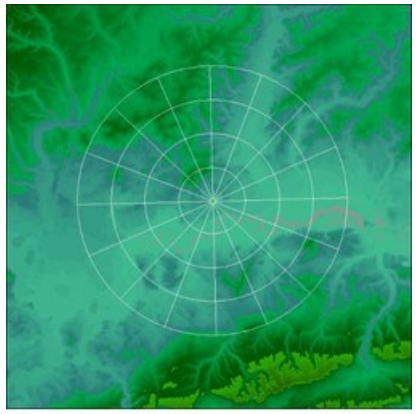
- Can we perform virtual measurements?





Point-to-area measurements (Ofcom)

- Multiple prediction models available in VHF/UHF range
  - Recommendations P.1546, P.452, P.1812, P.1411



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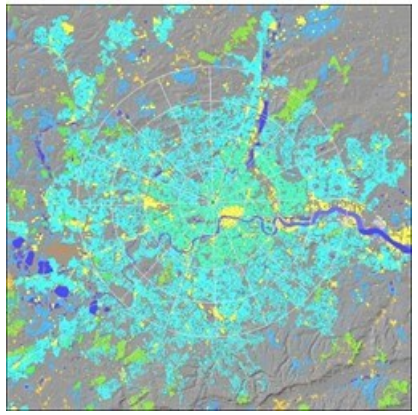

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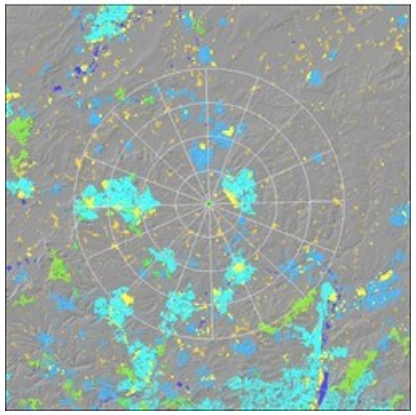
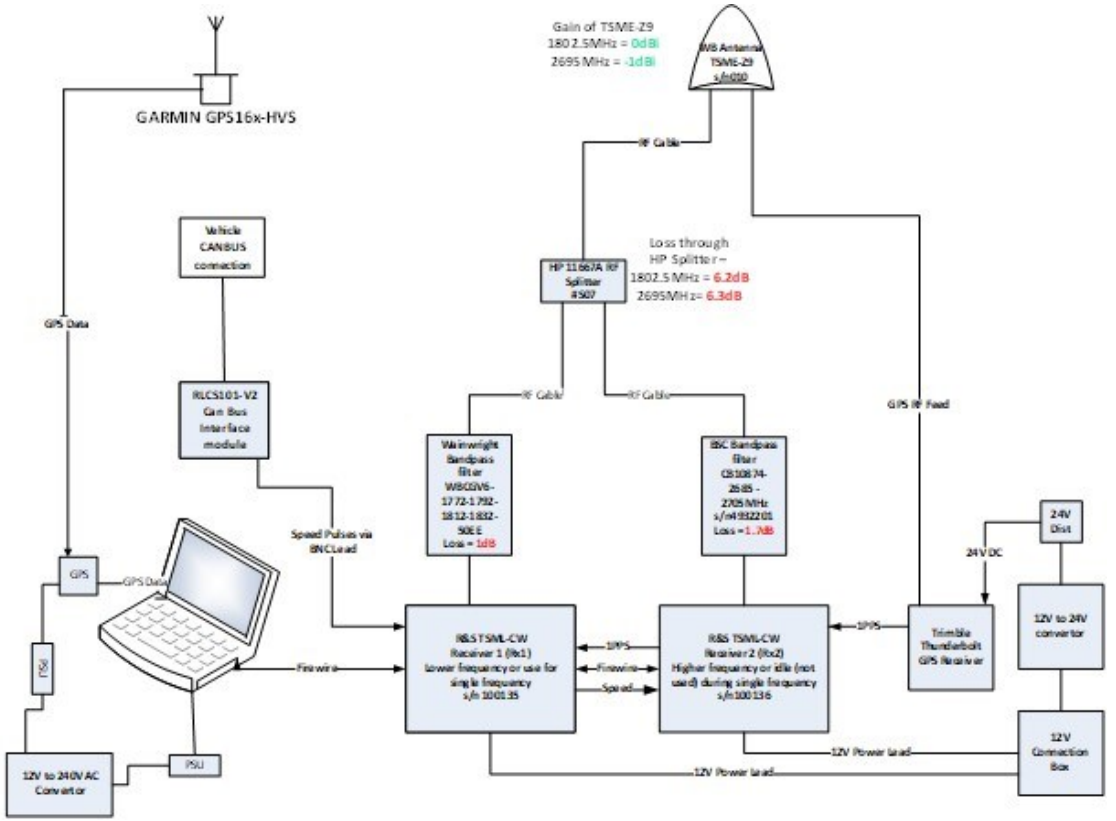


Stevenage >

Point-to-area measurements (Ofcom)

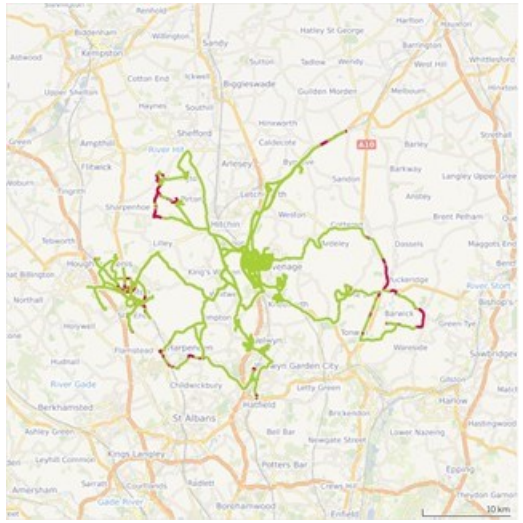
- CW transmitter, 20m mast
- Multiple frequencies measured simultaneously
  - 449 MHz
  - 916 MHz
  - 1 803 MHz
  - 2 695 MHz
  - 3 603 MHz
  - 5 850 MHz
- Lee sampling criterion

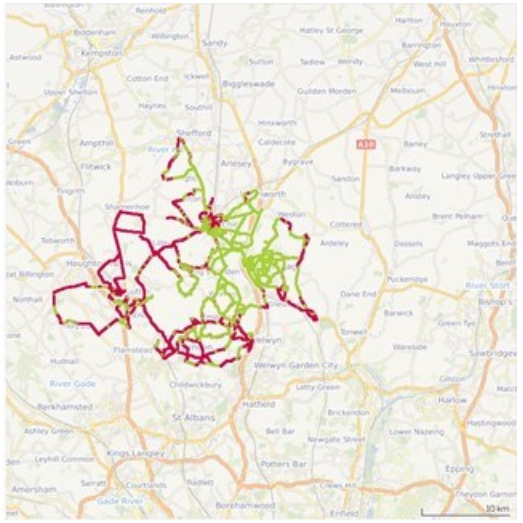


Ofcom measurements

- Drive test routes
- Threshold at S/N = 6dB

Stevenage
449 MHz & 5850 MHz





Southampton
449 MHz & 5850 MHz

Topographic data

- Data sets for model comparison
- GetMapping & Siradel products
- Reduced to 20m, 40m, 100m resolutions

Terrain and clutter databases specifications.

	Terrain (DTM)	Clutter (DLU)
Vendor	Getmapping plc	Siradel SAS
Source	Aerial Imagery	Landsat 8 pansharpened images
Year	Images captured between 2003 to 2014	Images captured in 2014/15
Accuracy	(x, y): 1.1 m (z): 1.5 m Max single point z error < +/- 4 m.	(x, y) 25- 50m
Base data resolution	2m and 5 m	Landsat 8 Images: 15m and 30m
Prediction resolution	20 m	20 m
Projection	OSGB 1936 (EPSG:27700)	OSGB 1936 (EPSG:27700)
Notes	Aerial images provide better accuracy than satellite-based data capturing methods such as IFSAR, LANDSAT, SRTM and etc.	Pansharpening a Landsat image is merging the 15m panchromatic band with the 30m multispectral band which brings more details to the image.

449 MHz
20m

449 MHz
100m

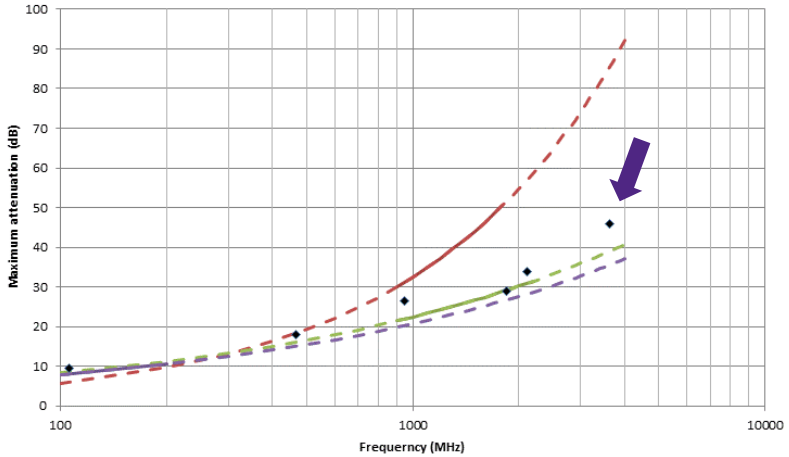
Next steps

- Ofcom are undertaking a substantial exercise of model comparison using this data
  - P.1812, P.452, P.1546 evaluated
  - Performance at different data resolutions
  - Appropriate use of clutter

- Initial results will be submitted to Working Party meetings in Montreal (June)
  - *Thanks to Clare Allen, Frances Riddoch & Afzal Lodhi of Ofcom for this material*

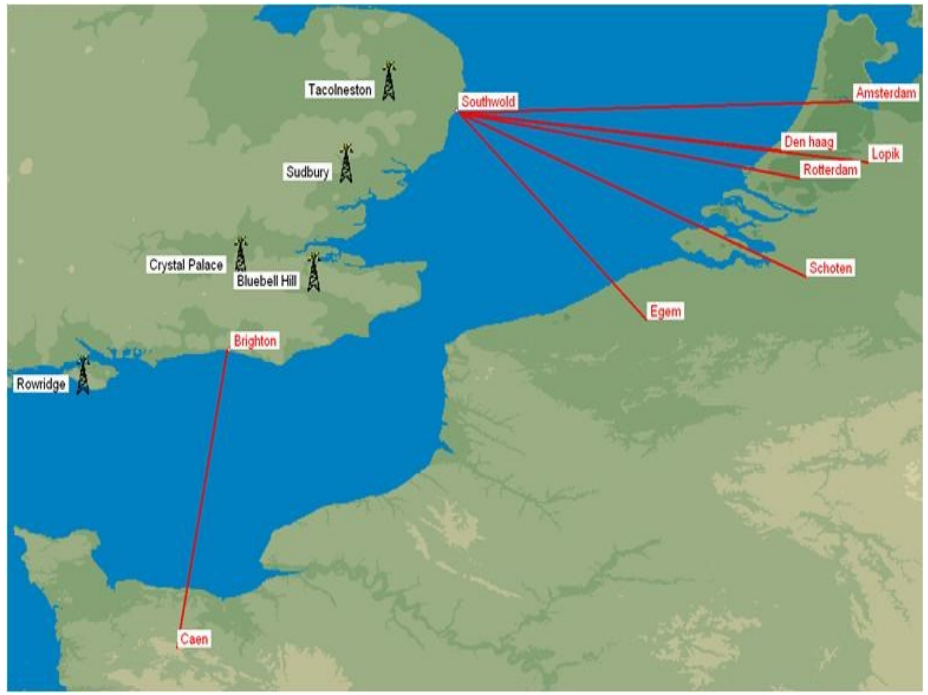
Other models – vegetation loss

- How much attenuation could be expected from 200m of vegetation at 3.6 GHz?
- ITU-R P.833 gives a simple prediction method.
  - Specific attenuation, γ (dB/m)
  - Maximum attenuation (A_m) limited by scattering and diffraction
- γ ~ 0.6dB at 3.5 GHz
- A_m is derived by exponential fit to a small measurement set



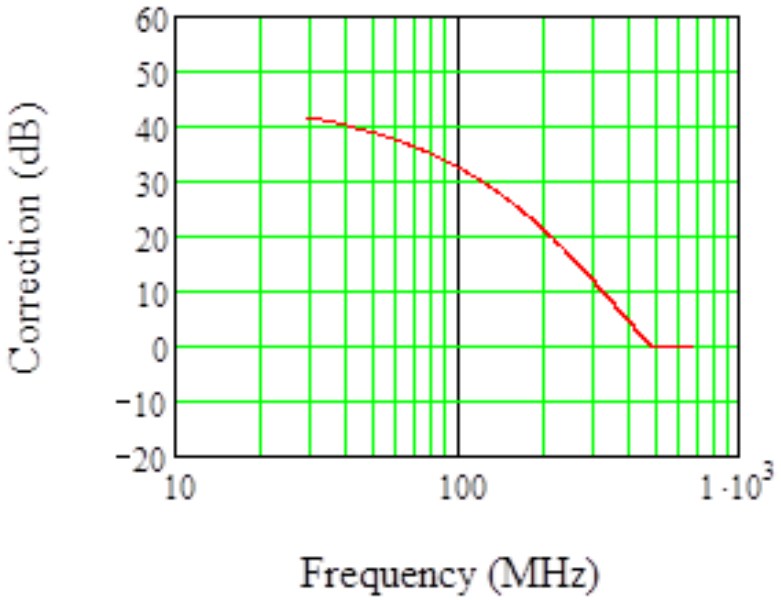
Other models – Tropospheric enhancement

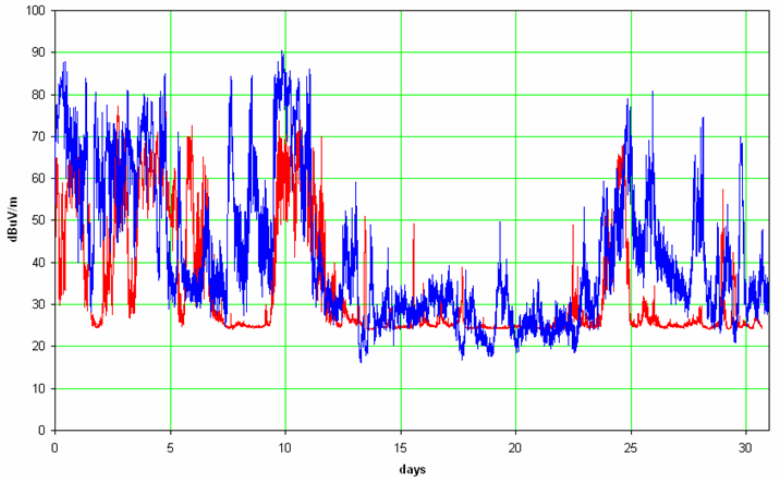
- Sea-path measurements
- TV transmitters
  - 500-600 MHz
  - France, Belgium & Holland

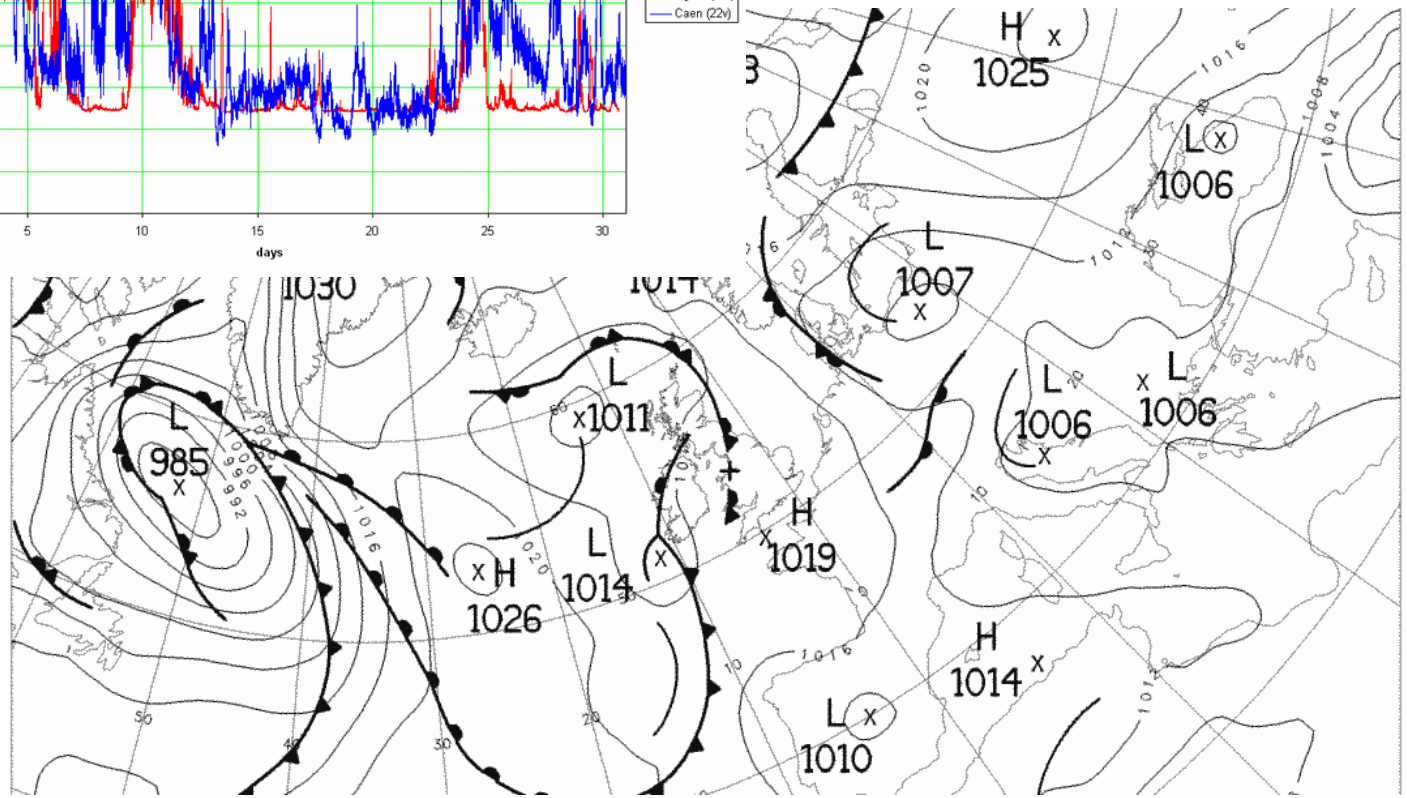


Other models – Tropospheric enhancement

- ‘LF correction’ for ducting models



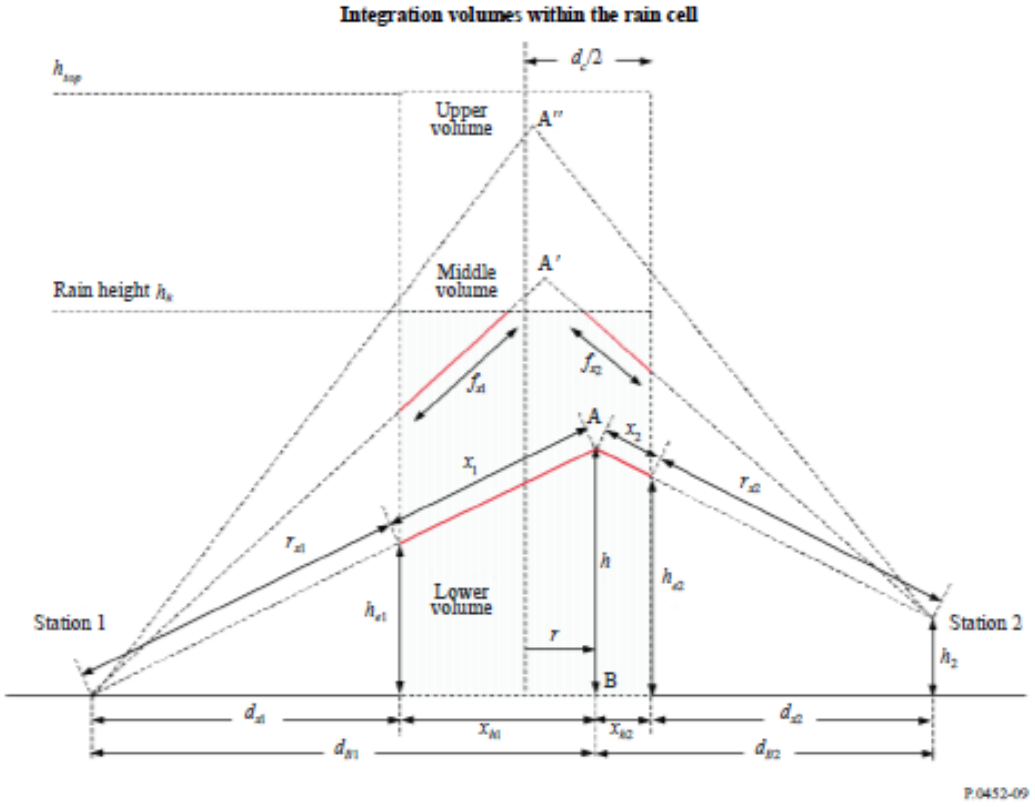




- ...but most short-term data is still from temperate latitudes

Other models – hydrometeor scatter

- P.452 hydrometeor scatter model (from COST 210)
- Intended for large-scale issues of interference between FSS and FS
  - Several iterations
  - Complicated to implement...numerical integration
  - Currently being re-examined
- Perhaps adapt for smaller-scale networks



Any questions?